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Transfer/transform relationships in continental rifts and margins and their control on syn- and post-rift denudation: the case of the southeastern Gulf of Aden, Socotra Island, Yemen

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Transfer zones are ubiquist features in continental rifts and margins, as well as transform faults in oceanic lithosphere. Here, we present the structural study of such a structure (the Hadibo Transfer Zone, HTZ) from the southeastern Gulf of Aden, in Socotra Island, Yemen. There, from field data, the HTZ is interpreted as being reactivated, obliquely to divergence, since early rifting stages. Then, from a short review of transfer/transform fault zone geometries worldwide, we derive a classification in terms of relative importance (1st, 2nd, 3rd order), geometry, and location. We suggest that the HTZ is a 1st order transfer fault zone as it controls the initiation of a 1st order oceanic transform fault zone. We then investigate the denudation history of the region surrounding the HTZ in order to highlight the interplay of normal and transfer/transform tectonic structures in the course of rift evolution. Samples belong from two distinct East and West domains of the Socotra Island, separated by the (HTZ). Tectonic denudation started during the Priabonian-Rupelian along flat normal faults and removed all the overlying sedimentary formations, allowing basement exhumation up to the surface ($\sim$ 1.2 - 1.6 km of exhumation). Forward t-T modelling of the data requires a slightly earlier date and shorter period for development of rifting in the E-Socotra domain (38 - 34 Ma), compared to the W-Socotra domain (34 - 25 Ma), which suggests that the HTZ was already active at that time. A second major event of basement cooling and exhumation (additional $\sim$ 0.7 - 1 km), starting at about $\sim$ 20 Ma, has only been recorded on the E-Socotra domain. This second denudation phase significantly post-dates local rifting period but appears synchronous with Ocean Continent Transition (OCT: 20 - 17.6 Ma). This late syn-OCT uplift is maximum close to the HTZ, in the wedge of hangingwall delimited by this transfer system and the steep north-dipping normal faults that accommodated the vertical motion. This particular pattern of uplift and denudation during the OCT reorganisation suggests that the late uplift of the margin can be strongly differential from a segment to another, depending on its previous extensional history.